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# LOW STAND DENSITY SPEEDS LODGEPOLE PINE TREE GROWTH

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## INTRODUCTION

To the silviculturist, judicious control of tree density throughout the life of a forest stand provides one of the primary avenues for optimizing returns from timber growing. Tree density is especially critical in the culture of lodgepole pine because stagnation from overcrowding is probably more pronounced in this species than in any other western conifer.

The first of a series of experiments, designed to provide foresters with better basic information on growth-growing stock relationships in lodgepole pine (*Pinus contorta*), was started in a 22-year-old stand in central Oregon in 1959. This note reports findings from the first 5-year growth period.

## THE EXPERIMENT

*The stand* chosen for this experiment originated after a fire in 1934 on an area that can support either ponderosa or lodgepole pine. Site quality for ponderosa pine (*Pinus ponderosa*) is in the very high, site class IV[1] range. Similarly, site quality for lodgepole pine is considerably above average for central Oregon.

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[1] Site quality determined with aid of site index curves contained in "Yield of Even-Aged Stands of Ponderosa Pine," by Walter H. Meyer, U.S. Dep. Agr. Tech. Bull. 630 (rev.), 59 pp., illus. 1961.

The experiment consists of ten 1/10-acre plots. Each of five level-of-growing-stock treatments was assigned to two plots at random.

Treatments were defined in terms of bole area. Bole area is the cambium area of the main stem. Lexen,[2] the originator of this density measure, explained many of its advantages as a basis for thinning control.

For the convenience of those not familiar with bole area, equivalents in terms of basal area and crown competition factor (CCF)[3] are also included in the various tables. Figure 1 further aids in visualizing the kind of treatment applied.

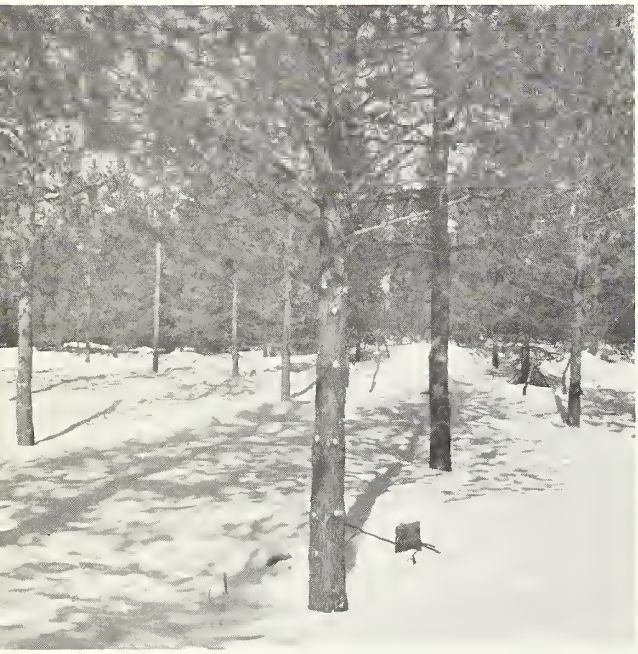

*Figure 1.--The 4,000-square-foot bole area treatment, shown at left, resulted in an average spacing of 18.7 feet.*

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[2] Lexen, Bert. Bole area as an expression of growing stock. J. Forest. 41: 883-885. 1943.

[3] Crown competition factor, in essence, compares growing space available to a tree with the area of shadow the crown of an open-grown tree of the same breast-high diameter would cast on level ground with the sun directly overhead. Because growing space available to a single tree is not readily determinable, the comparison is made on a group basis. A CCF of 100 means tree growing space and open-grown-tree shadow area are the same. A CCF of 50 means tree growing space is twice the open-grown-tree shadow and a CCF of 200 means growing space is half the open-grown-tree shadow area. Crown competition factor is further described by Krajicek, J. E., Brinkman, K. A., and Gingrich, S. F., in "Crown competition--a measure of density." Forest Sci. 7: 35-42. 1961.

Growing-stock levels initially chosen for testing were 7,500, 12,500, 17,500, 22,500, and 27,500 square feet of bole area per acre. After examination of the first 5-year growth data, levels were dropped to 4,000, 8,000, 12,000, 16,000, and 20,000 square feet, respectively. We plan to cut back to these latter levels at the end of each 5-year period.

Pretreatment density (table 1) was not high enough to provide the higher density treatments on all plots. Accordingly, there was very little difference between the two highest growing-stock levels after the 1959 thinning (table 2). However, stand density increased substantially by 1964 and was high enough on all plots to meet the revised 1964 treatment definitions.

Table 1.--Stand statistics before thinning lodgepole pine in central Oregon, 1959 (per-acre basis)

| Growing-stock level | Plot | Number of stems | Average d.b.h. | Basal area | Bole area | CCF | Site index[1] |
|---|---|---|---|---|---|---|---|
| | | | Inches | Sq. ft. | Sq. ft | | |
| 1 | 8 | 1,650 | 3.4 | 101.4 | 20,606 | 187 | 61 |
| (lowest) | 10 | 1,580 | 3.5 | 102.6 | 20,931 | 184 | 60 |
| | Average | 1,615 | 3.4 | 102.0 | 20,768 | 185 | 60 |
| 2 | 2 | 1,350 | 3.4 | 87.1 | 18,463 | 157 | 62 |
| | 4 | 1,010 | 4.0 | 90.0 | 16,586 | 142 | 71 |
| | Average | 1,180 | 3.7 | 88.6 | 17,524 | 150 | 66 |
| 3 | 1 | 1,670 | 3.5 | 110.3 | 24,522 | 196 | 65 |
| | 6 | 1,550 | 3.4 | 110.2 | 21,255 | 192 | 65 |
| | Average | 1,610 | 3.4 | 110.2 | 22,888 | 194 | 65 |
| 4 | 3 | 1,940 | 3.2 | 106.8 | 24,447 | 206 | 65 |
| | 5 | 1,370 | 3.4 | 85.8 | 17,820 | 157 | 61 |
| | Average | 1,655 | 3.3 | 96.3 | 21,134 | 182 | 63 |
| 5 | 7 | 1,630 | 3.3 | 94.6 | 21,925 | 179 | 60 |
| (highest) | 9 | 2,140 | 2.9 | 96.5 | 22,355 | 204 | 58 |
| | Average | 1,885 | 3.1 | 95.6 | 22,140 | 192 | 59 |

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[1] Site index at index age 50 years determined with the aid of height-over-age curves contained in: Dahms, Walter G. Gross and net yield tables for lodgepole pine. U.S. Forest Serv. Res. Pap. PNW-8, 14 pp., illus. 1964.

Table 2.--Stand statistics of lodgepole pine in central Oregon after 1959 thinning, before 1964 thinning, and after 1964 thinning (per-acre basis)

| Growing-stock level | Number of stems | Average spacing | Average d.b.h. | Average height | Basal area | Bole area | CFF | Volume[1] |
|---|---|---|---|---|---|---|---|---|
| | | Feet | Inches | Feet | Sq. ft. | Sq. ft. | | Cu. ft. |
| Immediately after 1959 thinning: | | | | | | | | |
| 1 | 405 | 10.4 | 4.2 | 26.0 | 41.7 | 7,330 | 64 | 537 |
| 2 | 610 | 8.4 | 4.4 | 28.2 | 70.0 | 12,454 | 102 | 979 |
| 3 | 925 | 6.9 | 4.0 | 27.2 | 85.3 | 16,538 | 136 | 1,152 |
| 4 | 1,345 | 5.7 | 3.4 | 24.6 | 92.4 | 19,305 | 164 | 1,186 |
| 5 | 1,705 | 5.1 | 3.0 | 22.8 | 93.6 | 20,248 | 182 | 1,122 |
| Just before 1964 thinning: | | | | | | | | |
| 1 | 405 | 10.4 | 5.2 | 32.4 | 62.0 | 10,496 | 84 | 875 |
| 2 | 610 | 8.4 | 5.0 | 34.1 | 88.6 | 16,343 | 121 | 1,362 |
| 3 | 920 | 6.9 | 4.5 | 33.2 | 107.4 | 21,822 | 158 | 1,657 |
| 4 | 1,315 | 5.8 | 3.8 | 30.3 | 113.6 | 24,700 | 184 | 1,656 |
| 5 | 1,645 | 5.1 | 3.4 | 27.9 | 115.4 | 25,078 | 201 | 1,527 |
| Immediately after 1964 thinning: | | | | | | | | |
| 1 | 125 | 18.7 | 6.2 | 34.5 | 26.8 | 4,302 | 33 | 409 |
| 2 | 235 | 13.6 | 5.9 | 38.0 | 45.7 | 7,972 | 58 | 734 |
| 3 | 420 | 10.2 | 5.2 | 36.0 | 64.6 | 12,236 | 88 | 1,023 |
| 4 | 675 | 8.0 | 4.5 | 33.5 | 78.8 | 16,100 | 116 | 1,200 |
| 5 | 1,060 | 6.4 | 4.0 | 30.4 | 95.0 | 19,970 | 154 | 1,326 |

[1] Volume of entire stem, inside bark.

Excess trees cut to achieve desired densities were the diseased and small individuals of poor thrift. Goal was to leave the best trees with as uniform spacing as possible.

Tree measurements taken at the beginning and ending of the growth period fall into two categories. One consists of height and diameter of all plot trees. The other includes diameter and bark thickness at intervals up the stems of five sample trees per plot. Formulas calculated from the sample trees express volume and bole area of entire stem as a function of diameter and height for each measurement date. These formulas were used to calculate plot volume and bole area.

Soil moisture was measured with a neutron probe.[4] The first measurement was made in the spring of 1961, shortly after the winter snow had melted. This reading was a good estimate of the fully charged soil's water-holding capacity. Another measurement was taken at the end of the growing season just before fall rains began. A water use[5] estimate was obtained as the difference between the beginning and ending soil moisture measurements.

Differences between the spring 1961 and spring 1962 soil moisture measurements were very small. Furthermore, winter precipitation always substantially exceeded soil water-holding capacity. Therefore, the spring 1962 measurement was accepted as the initial soil water charge for succeeding years. An estimate of water use for a particular growing season was obtained as the difference between the spring 1962 measurement and a measurement at the end of the growing season in question.

## RESULTS

Diameter growth was greatest in the lowest level of growing stock and least in the highest level. Principal difference was between the lowest stand density level and the other four treatments (fig. 2). This relationship was consistent and statistically significant whether diameter growth of all trees or only that of the largest diameter trees per acre (100, 200, or 300) were compared.

Height growth ranged from a low of 4.7 feet per tree on one plot to a high of 6.5 feet on another. Height growth averaged 5.8 feet over all plots. Differences between treatments were small and statistically nonsignificant. This relationship was true whether all trees or only a limited number of tallest trees were considered.

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[4] Oregon State University, through Dr. C. T. Youngberg, supplied the neutron probe. Methods of soil moisture measurement closely followed those described in "Effect of Tree Spacing and Understory Vegetation on Water Use in a Pumice Soil," by James W. Barrett and C. T. Youngberg (Soil Sci. Soc. Amer. Proc. 29: 472-475, illus. 1965), except that sampling points were mechanically distributed over individual plots rather than being located at the center of a square formed by four trees.

[5] Water use here means difference between water in the soil at the end of snowmelt in the spring and end of the growing season. Direct evaporation from the soil is included. Not included were additions to soil moisture in the form of growing-season precipitation. However, very little precipitation fell during the growing season.

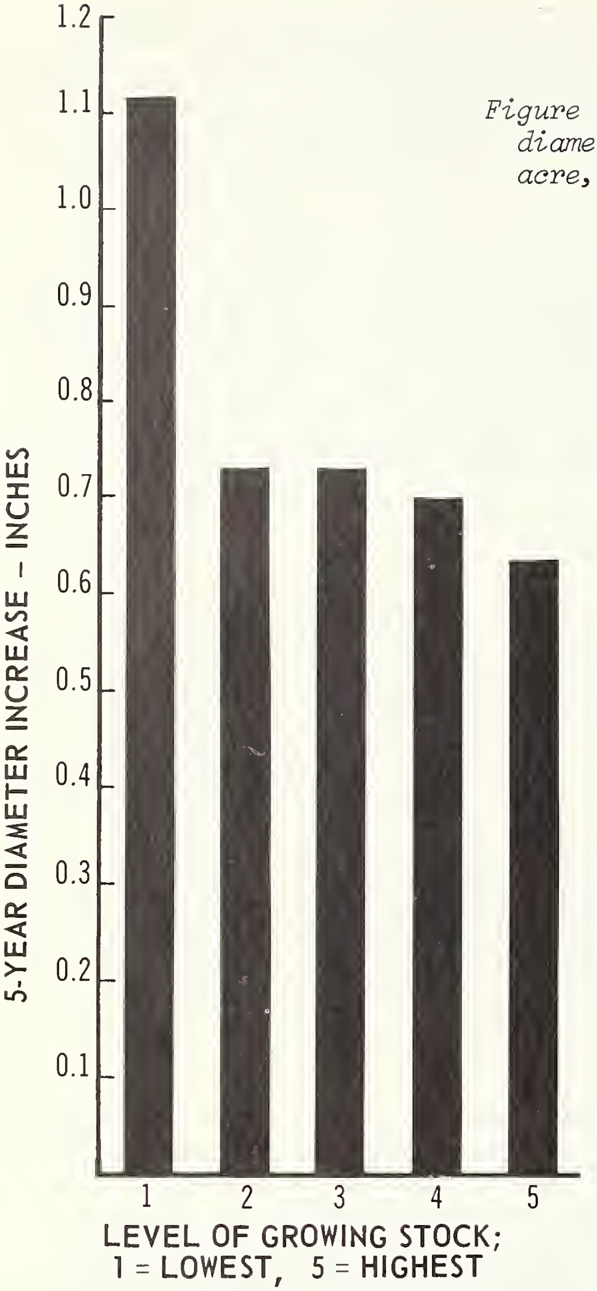

*Figure 2.--Five-year increase in average diameter of the 100 largest trees per acre, by levels of growing stock.*

Volume increment of a limited number of largest trees was substantially greater on plots with lowest levels of growing stock (fig. 3). For example, the 100 largest trees per acre on the lowest level-of-growing-stock plots added almost as much volume as the 200 largest trees at the highest density level. This tendency was statistically significant. Thus, the main goal of stand density control, transfer of volume increment from many small useless trees to a lesser number of larger, potentially higher valued trees, was accomplished.

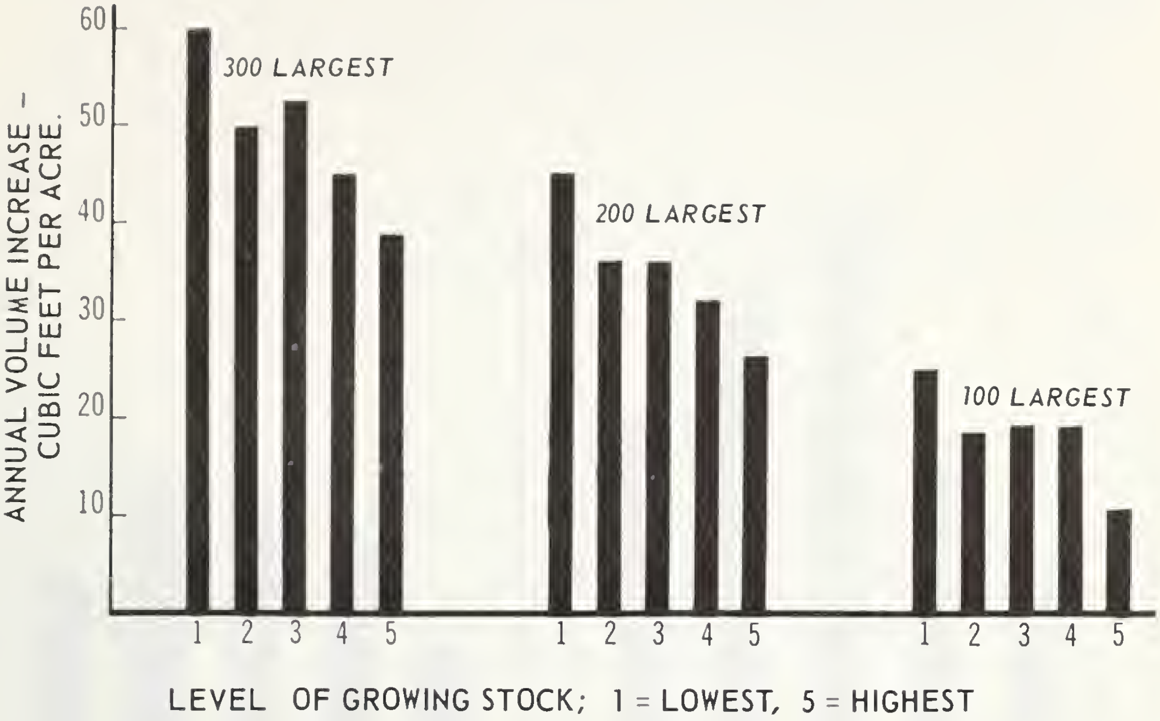

*Figure 3.--Volume increase of the 100, 200, and 300 largest (diameter) trees per acre, by growing-stock level.*

Volume increment of all trees was somewhat less on the lowest and highest levels-of-growing-stock treatments than on the intermediate ones (fig. 4). However, statistical analysis failed to show that differences were significant.

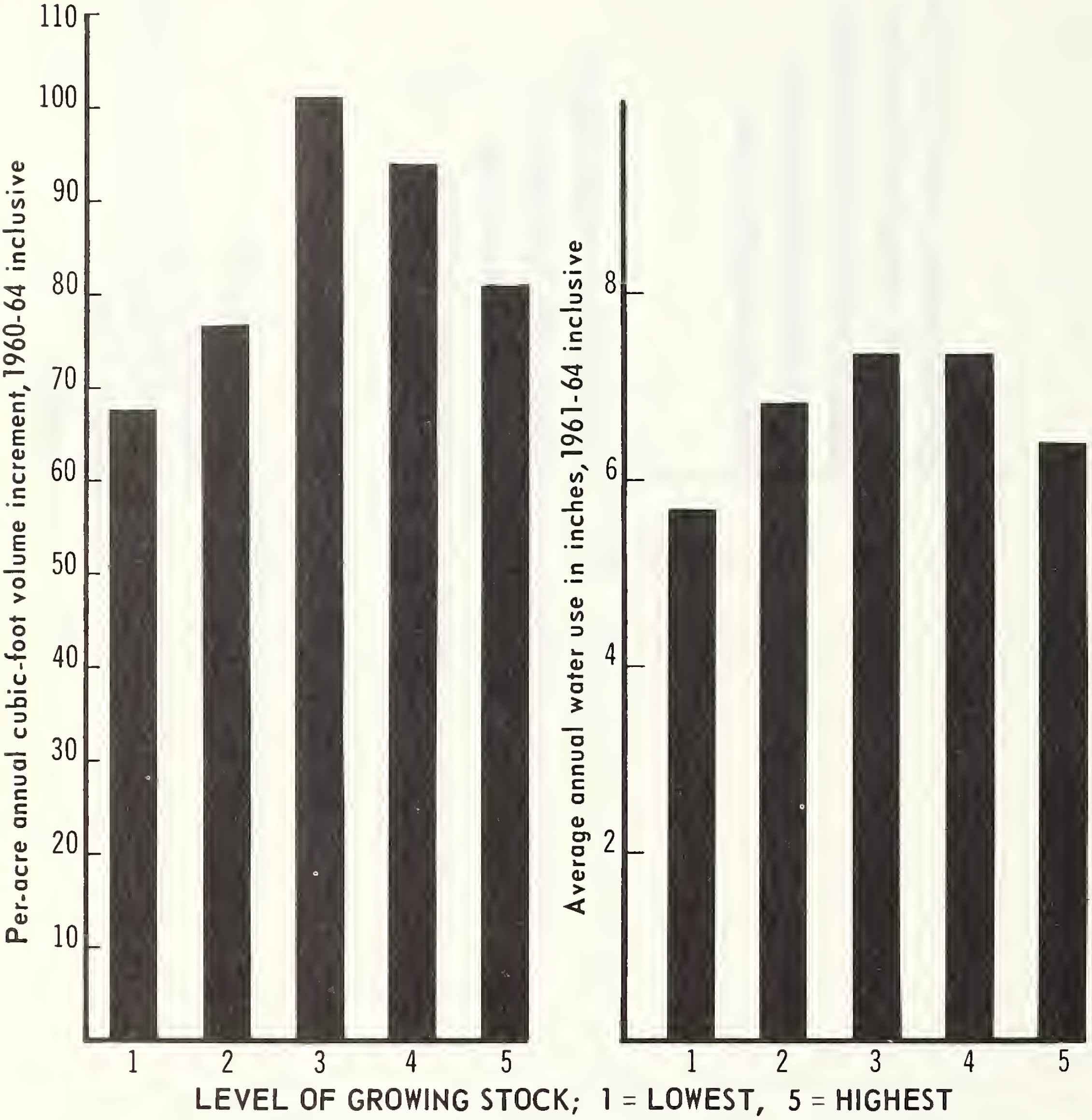

*Figure 4.--Volume increment and soil moisture use, by growing-stock level.*

Stand-density increase was very rapid (table 3). Density increased on the lowest level-of-growing-stock treatment from 7,300 square feet of bole area per acre to 10,500 square feet in 5 years. This was 61 percent of the difference between initial density and beginning density of the next higher level-of-growing-stock treatment. In terms of basal area, the comparable increase amounted to 72 percent.

Table 3.--Five-year change in stand density by growing-stock level for lodgepole pine in central Oregon (per-acre basis)

| Growing-stock level | Bole area | | | Basal area | | |
|---|---|---|---|---|---|---|
| | 1959 | 1964 | Increase | 1959 | 1964 | Increase |
| | M square feet | | | Square feet | | |
| 1 (lowest) | 7.3 | 10.5 | 3.2 | 41.7 | 62.0 | 20.3 |
| 2 | 12.5 | 16.3 | 3.8 | 70.0 | 88.6 | 18.6 |
| 3 | 16.5 | 21.8 | 5.3 | 85.3 | 107.4 | 22.1 |
| 4 | 19.3 | 24.7 | 5.4 | 92.4 | 113.6 | 21.2 |
| 5 (highest) | 20.3 | 25.1 | 4.8 | 93.6 | 115.4 | 21.8 |

Records of soil moisture use, including surface evaporation, are available for only four of the five growing seasons included in the growth record. Nevertheless, a regression of 5-year volume increment on 4-year water use, by plots, showed a significant correlation (fig. 5), indicating that more soil moisture was used where more wood was produced.

When moisture use is tabulated by individual years (table 4), additional insight is furnished on the probable influence of stand density on water use (and ultimately on wood production). In 1961 (second growing season after the original thinning) and again in 1965 (immediately following the second thinning), differences in moisture use between treatments were significant. Low soil moisture use by the low density treatment during these years was the principal reason for differences. In the intervening years, differences in moisture use among treatments were not statistically significant. These trends suggest that the heaviest thinning treatment lowered stand density enough to reduce water use for the first year or two;

however, recovery of roots and crowns was sufficiently rapid to eliminate treatment-caused differences or reduce them to nondetectable size by the third year after thinning.

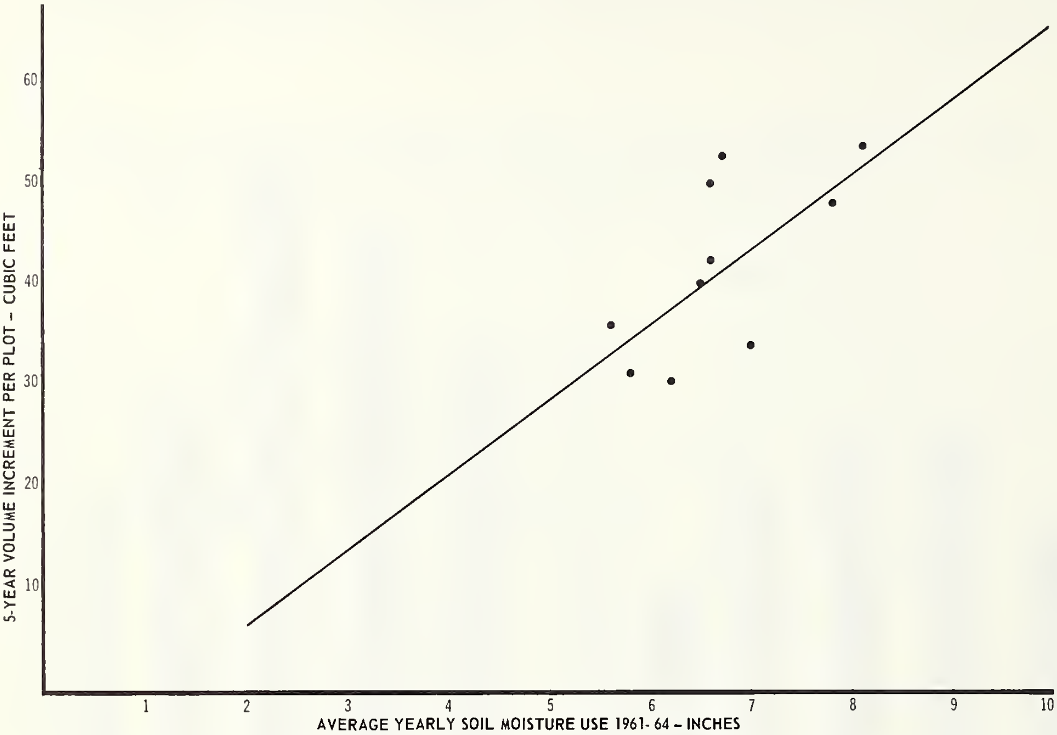

*Figure 5.--Regression of volume increment on water use.*

Table 4.--Average moisture use by treatments and years for lodgepole pine in central Oregon (inches)

| Treatment | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|
| 1 (lowest density) | 5.2 | 6.4 | 4.6 | 6.6 | 3.5 |
| 2 | 7.2 | 7.4 | 5.6 | 7.0 | 5.4 |
| 3 | 7.4 | 8.0 | 6.0 | 7.7 | 6.1 |
| 4 | 7.4 | 8.2 | 6.0 | 7.6 | 6.0 |
| 5 (highest density) | 6.3 | 7.5 | 5.0 | 6.9 | 6.2 |

## DISCUSSION

First results from this experiment confirm that good rates of diameter growth can be attained in young lodgepole pine if trees have ample growing space. They also demonstrate that growth capacity of the site is redistributed very rapidly following a broad range of thinning intensities. Total volume of wood produced per acre over the 5-year period was not significantly different among growing-stock levels, although annual moisture use records suggest a temporary reduction probably occurred in the lowest level. Moisture records further demonstrate that volume production per unit area is closely related to use of water during the growing season.

In terms of Oregon markets, trees in the experimental stand are well below merchantable size. A primary management goal in such premerchantable stands would usually be to eliminate stems that die before they reach usable size and concentrate growth capacity on only those stems that will contribute to intermediate or final harvests. During this premerchantable stage of development, total wood production per acre is of secondary importance. Initial results indicate this goal can be achieved with very low levels of growing stock and suggest either that initial spacings of lodgepole pine should be very wide or that precommercial thinnings may have to be repeated at frequent intervals.

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